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USE OF HIGH LIPID FEEDS TO MEET ENERGY NEEDS OF DAIRY AND FEEDLOT CATTLE AND TO MAXIMIZE DESIRABLE FATTY ACID CONTENT OF BEEF AND MILK

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The Use of High Lipid Feeds to Meet Energy Needs of Dairy and Feedlot Cattle

Final Report

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Submitted by J. J. McKinnon & D.A. Christensen

Department of Animal and Poultry Science
University of Saskatchewan
Saskatoon, SK S7N 5A8

Tel: (306) 966-4152
Fax: (306) 966-4151
E-mail: mckinnon@sask.usask.ca

Executive Summary

The objective of this project is to determine the value of whole sunflower, canola, and flax seed in dairy and beef rations. The nutritional significance of these oil seeds lies in their high energy density which may improve performance of cattle and also may improve the fatty acid composition of the fat for human health. It has been found that either raw or roasted sunflower seed are highly palpable to dairy cows and are not sorted out or left in the feed bunk. We have also found that they maintain milk yield at close to 40 kgs daily, similar to the control ration, and also maintain fat percentage and yield. There is however a slight reduction in protein content in the milk when sunflower seed is fed. Feeding of sunflower seed either raw or roasted increases conjugated linoleic acid and alpha- linoleic acid content of milk compared to the control ration. Roasted sunflower has a greater effect then raw sunflower in this respect. Feeding an extruded flax seed or roasted soybean product increases the CLA content of milk and colostrum and also increases the oleic acid content of milk. Sheep colostrum contains significantly more CLA than sheep milk, while cow's colostrum does not contain a high level of CLA compared to milk.

Work carried out in our first finishing beef cattle trial indicated that sunflower addition at the 10% inclusion level (as fed) in a 80% barley grain based finishing diet resulted in reduced dry matter intake, similar gains and as a result significantly improved feed efficiency relative to cattle fed a standard feedlot finishing diet. No adverse effects on health (i.e. acidosis) or on carcass quality were observed with feeding sunflowers. Linoleic acid content of adipose tissue was increased in a linear manner with sunflower seed inclusion in the diet. Our second study examined the strategic supplementation of either flax or sunflower seeds on feedlot performance and carcass characteristics of finishing cattle. The results of this trial indicate that inclusion of ground flax or whole sunflower into the diet of feedlot cattle may result in an initial and transitory decline in intake with subsequent impacts on gain. However, by the time cattle were sent to slaughter, the only impact of dietary inclusion of ground flax or whole sunflower was an increase in ribeye area with subsequent impact on estimated yield. Fatty acid profile of fat extracted from ribeye tissue showed that sunflower feeding during the last 60 days increased the linoleic acid content while flax feeding increased the linoleic acid content of beef. Both are essential in the human diet and thus such feeding may pose a route to value-added beef products in a manner beneficial to human health.

Knowledge gained from this research will enable greater understanding of the effects of an unsaturated fat source on performance and product quality of lactating and growing cattle. From the point of view of providing energy and protein to high performance ruminant animals,

high lipid feeds such as flax and sunflower have proven to be of equal or superior to conventional feeds. Nutritionists need to recognize the limitations on fat levels of ruminant diets and not exceed 7% of the diet dry matter in order to minimize intake and digestibility concerns. Economics of these feeds also have to be considered when including in the diet. Of particular significance is the increased content of dairy and beef products from cattle fed sunflower and flax. Increased content of essential fatty acids such as linoleic acid, conjugated linoleic acid and linolenic acid offer the potential to value add ruminant products and market to domestic and international consumers who focus on health issues.

It may also interest the Board that we have continued this work, particularly with cattle on a commercial level. We have set up trials with Pound-Maker Agventures and a feedlot in Alberta to look at the commercial feeding of sunflowers, flax and canola. This work will not only look at feedlot performance, but carcass quality and green house gas emissions. This new avenue of research is funded by the Green house Gas Mitigation Program run through the Canadian Cattlemen's Association.

Finally, sincere appreciation is expressed by the author's to the Agriculture Development Fund of Saskatchewan Agriculture and Rural Development for funding the research in this report.

A. Technical Report

i. Dairy Related Research

Three dairy projects have been supported through this grant. The first one consists of a trial conducted as part of Amanda Kroeker's M.Sc. studies. This trial was carried out to determine if roasted or raw sunflower seeds are an effective source of energy and if they will alter milk fatty acid composition favorably. The trial consisted of a double 4x4 Latin square design with a twenty eight day periods and milk yield and milk composition measured during the final 10 days of each period. The basic ration consisted of 49.5 percent of forage and the concentrate ingredients shown in table 1. The control ration is similar to that used for the high production total mixed ration group in the University herd. Table 2 summarizes dry matter intake and chewing behavior. The dry matter intake was similar to or slightly reduced compared to the control ration due mainly to the higher energy content of the sunflower seed rations. Surprisingly the cows tended to increase their total daily chewing time to over 800 minutes when sunflower seeds were fed. This was due mainly to an increase in rumination time rather than eating time. The significance of this observation is that whole sunflower seeds have forage- like effect in terms of maintaining or slightly increasing rumination time. Table 3 shows the effect on milk yield which was not statistically significant (PL.05) for either actual or 3.5 percent fat corrected milk yield. Milk fat percentages were maintained, however, milk protein content was significantly reduced on all of the sunflower seed treatments. This is probably due to the effect of the long chain unsaturated fatty acids which either act through inhibiting fatty acid uptake by memory gland cells or contribute to the formation of one of the acid isomers that interferes with fatty acid metabolism in the mammary gland. Table 4 shows the effect on fatty acid composition with the roasted sunflower seed fed at approximately 1.5 kgs per day causing the greatest increase in the conjugated linoleic acid (CLA) content. This ration also resulted in the greatest increase in C 18:3. Oleic acid (C 18:1) was substantially reduced with the feeding of the sunflower seed.

In a second production trial using free stall groups of cows fed a total mixed ration a slightly different result was obtained. In this trial 0.6 kgs of dry matter from sunflower seed was fed. Fatty acid was substituted for total mix ration dry matter and fed in a switch back design. The

control ration was fed for a three week period followed by the sunflower ration being fed for three weeks and then the control ration being fed for the three weeks with milk yield and composition being determined in the last two days of each feeding period. Fatty acid content of the milk was not measured. Average milk yield was increased by 1.7 kgs and 3.5 were fat corrected milk increased by 1.8 kgs. Persistency of lactation increased and milk protein yield per day was maintained (Table 5). As shown in Table 6, dry matter intake was slightly reduced when cows were fed sunflower seed and although cows did not lose weight, they did not gain as much weight as cows on the control ration. Several Saskatchewan companies have shown an interest in developing and distributing an extruded flax product. Several years ago Extra Pro was developed using 50 percent canola seed and 50 peas. Now this product is now being used extensively by O and T Farms in their poultry operation and is being sold to some swine producers. At present O and T Farms are operating six extruders at close to capacity producing this product. O and T Farms and Werner Agra have also shown interest in developing a flax seed based product. Preliminary work on the product consisting of 50 percent flax seed and 50 percent peas showed that is much less palpable then the canola pea product. As part of this project is also supported by the ADF strategic ruminant nutrient and biotech program. The effect of the flax seed pea blend (LinPro) was compared to a control ration and also to a ration containing whole roasted soy beans. From a previous research it is known that both flax seed and soy bean oil may have a beneficial effect on fatty acid composition from a human health point of view. It is also of interest to know if the fatty acid change in colostrum from feeding these products may have a positive effect on calf health. For this reason a series of measurements on milk and colostrum were made in which either the extruded flax product or whole roasted soybeans were fed at up to 1 kg daily from 7 days prior to calving through 10 days post calving. Table 7 shows the composition of milk 10 days after calving for the control of the flax and soybean rations. Table 8 contains similar information for colostrum. Both the flax and soy bean rations resulted elevated at CLA content and also elevated oleic acid. The colostrum CLA values are substantially higher than for milk and in this case the oil seeds did not increase the oleic acid content of the fat. Table 9 contains a summary of fatty acid composition of milk and colostrum from cows and sheep when no supplementary fat from oil seeds was fed. Sheep milk and colostrum contain significantly more (CLA; C 18:2 c9, t11) compared to cows. Both sheep milk and colostrums contain substantial levels of C10:0 fatty acids.

Studies at the University of Alberta have estimated human diet intakes range from 52 to137 mgs of CLA daily. Consumption of 1 litre of milk containing 7 mgs. of CLA per gram of fat would supply 224 mgs. of CLA daily. This is twice the amount that would be found in normal milk.

Table 1. Composition of Experimental Diets.

	Treatment			
Variable	Control	RWSF[1]	RDSL[2]	RDSH[3]
		%DM		
Forage Mixture (50% DM):				
Alfalfa Hay	21.3	21.3	21.3	21.3
Barley Silage	28.2	28.2	28.2	28.1
Concentrate (50% DM):				
Barley	28.7	27.1	27.1	25.6
Wheat	2.5	2.4	2.4	2.3
Oats	2.5	2.4	2.4	2.3
Raw Sunflower Seed	—	2.8	—	—
Roasted Sunflower Seed	—	—	2.8	5.6
Soybean Meal	6.0	5.7	5.7	5.4
Canola Meal	5.0	4.8	4.8	4.5
Mineral –Vitamin Mix	1.5	1.4	1.4	1.4
Wheat Distillers Dried Grains	1.0	0.9	0.9	0.9
Corn Gluten Meal	1.0	0.9	0.9	0.9
Molasses	1.0	1.0	1.0	0.9
Cobalt-Iodized Salt	0.3	0.3	0.3	0.3
Canola Oil	0.3	0.3	0.3	0.3
Sodium Bicarbonate	0.3	0.3	0.3	0.3
Dynamite	0.1	0.1	0.1	0.1

[1]RWSF: Whole raw sunflower seeds at lower level of inclusion (0.75 kg/d as fed).

[2]RDSL: Whole roasted sunflower seeds at lower level of inclusion (0.75 kg/d as fed).

[3]RDSH: Whole roasted sunflower seeds at higher level of inclusion (1.5 kg/d as fed).

Table 2. Effect of Whole Sunflower Seeds on Dry Matter Intake and Chewing Behavior.

Variable	Treatment				
	Control	RWSF[1]	RDSL[2]	RDSH[3]	SEM
DMI, kg/d	26.0	24.3	25.7	24.3	0.91
DMI, %BW	4.06	3.88	4.08	3.81	0.14
CHEWING BEHAVIOR					
MIN/D					
Eating	261	260	263	267	14.2
Ruminating	534	540	541	562	14.3
TCA	795	800	804	829	16.6
MIN/KG DM					
Eating	10.1	11.1	10.3	11.5	0.84
Ruminating	21.0	23.8	21.5	23.9	1.24
TCA	31.0	35.0	31.6	35.0	1.89

[1]RWSF: Whole raw sunflower seeds at lower level of inclusion (0.75 kg/d as fed).
[2]RDSL: Whole roasted sunflower seeds at lower level of inclusion (0.75 kg/d as fed).
[3]RDSH: Whole roasted sunflower seeds at higher level of inclusion (1.5 kg/d as fed).

Table 3. Effect of Whole Sunflower Seeds on Milk Yield and Components.

Variable	Treatment				
	Control	RWSF[1]	RDSL[2]	RDSH[3]	SEM
MILK YIELD					
Actual, kg/d	39.3	38.3	39.0	38.8	0.97
3.5 % FCM, kg/d	40.8	40.2	40.3	40.1	0.94
MILK COMPONENTS					
Fat, %	3.75	3.80	3.72	3.72	0.05
Protein, %	3.28[a]	3.17[b]	3.18[b]	3.15[b]	0.03
Lactose, %	4.49	4.51	4.54	4.51	0.01
MUN, %	8.04	7.95	7.88	7.70	0.11
Total Solids, %	12.70	12.69	12.72	12.60	0.05

[a,b] represents significant differences between treatments ($P<0.01$).
[1]RWSF: Whole raw sunflower seeds at lower level of inclusion (0.75 kg/d as fed).
[2]RDSL: Whole roasted sunflower seeds at lower level of inclusion (0.75 kg/d as fed).
[3]RDSH: Whole roasted sunflower seeds at higher level of inclusion (1.5 kg/d as fed).

Table 4. SUNFLOWER PRODUCTION TRIAL – MILK FATTY ACID PROFILES

Unit: % in Fat

	C12:0	C14:0	C14:1	C16:0	C 16:1	C18:0	C 18:1	C 18:2 cis-9,12	CLA	Alpha C18:3
CONTROL	3.78	7.94	0.00	20.86	0.00	2.53	14.80	1.70	0.00	0.00
RAW	3.02	5.96	0.83	14.90	1.55	5.60	3.97	2.03	0.23	2.08
RTSL	3.24	6.89	0.38	20.04	1.10	7.16	7.50	3.18	0.34	2.14
RTSH	4.42	6.37	0.33	16.86	0.96	5.76	7.60	2.22	0.50	3.15

RTSL= ROASTED SUNFLOWERS AT 0.75 KG/D

RTSH= ROASTED SUNFLOWERS AT 1.5 KG/D

Table 5. Effect of whole sunflower seeds on milk yield and composition.

	Control	Sunflowers
Milk yield, kg/day	35.0	36.7
Persistency of yield, %	91.1	100.2
Milkfat[1], %	3.54	3.55
Milk fat yield, kg/day	1.21	1.29
3.5% FCM yield, kg/day	35.3	37.1
Persistency of FCM, %	93.3	98.0
Milk protein[2], %	3.58	3.47
Milk protein yield, kg/day	1.24	1.26
Lactose[2], %	4.58	4.64
Milk total solids[1], %	13.0	12.8
Somatic cell count[2], (000)	63.4	51.2

[1]Babcock procedure, Animal and Poultry Science Department, University of Saskatchewan, Saskatoon, SK.
[2]Provinical Dairy Laboratory, Regina, SK.

Table 6. Effect of whole sunflowers seeds on feed intake and utilization.

	Control	Sunflowers
TMR DM intake, kg/day	27.1	25.3
Sunflower DM intake, kg/day	0.00	0.60
Total DM intake, kg/day	27.1	25.9
DM intake, kg/100 kg 3.5% FCM	77.3	71.6
Bodyweight change, kg/day	0.77	0.01

Table 7. Milk fatty acid composition of cows milk* fed a Control diet or supplemented with Roasted soybean or Flaxseed.).

	Milk fatty acids, mg/g of FAME			
Fatty Acid	Control	Linpro	Soybean	SEM
C12:0	16.4	17.4	19.1	2.12
C14:0	71.5	55.9	56.6	3.56
C14:1c	6.29	5.32	5.25	0.91
C14:1t	1.44	1.37	1.43	0.09
C16:0	298	276	266	4.48
C16:1	26.6	29.3	26.9	1.72
C18:0	120	175	167	3.95
C18:1 t10	4.32	17.6b	23.2a	1.12
C18:1*c*9	333b	379a	368a	4.18
C18:1*t*11	11.9b	12.9b	14.1a	0.46
C18:2*c*9*c*12	18.5	22.8	23.1	1.71
C18:2*t*10, *c*12	1.39b	2.50a	2.89a	0.07
C18:3	14.3	13.2	11.6	1.40
C18:2 c9,t11(CLA)	4.02b	5.63a	6.99a	0.23

*Cows (n=36) were supplemented with either flaxseed (Linpro) or soybean 7d prior to calving thru 10d post calving. Milked for d10.

Table 8. Fatty Acid Composition of Colostrums from cows fed a Control diet or supplemented with Roasted soybean or Flaxseed (Cows were supplemented with either flaxseed (Linpro) or soybean 7d prior to calving thru 10d post calving. (Average d1 &2)).

	Colostrum fatty acids, mg/g of FAME			
Fatty Acid	Control	Linpro	Soybean	SEM
C12:0	21.5	27.5	22.0	1.71
C14:0	91.1	115	104	8.06
C14:1	5.05	7.85	5.48	1.14
C16.0	340	376	343	10.5
C16:1	23.7	26.8	23.1	0.94
C18:0	112	100	116	6.72
C18:1*c*9	327	282	312	17.2
C18:1*t*10	3.11	3.01	3.42	0.24
C18:1*t*11	11.9	12.9	13.1	0.46
C18:2*c*9*c*12	18.5	22.8	22.1	1.71
C18:2*t*10,*c*12	1.22	1.41	1.50	0.17
C18:2*c*9,*t*11	3.69	4.14	4.27	0.33
C18:3	12.2	10.3	14.2	1.26

Table 9. Comparison of fatty acids composition of milk* and colostrums* from cows and sheep (Milk was collected d10 post calving; colostrums average d1&2. Note; the cow milk and colostrum is data from cows fed control diet i.e. no supplements with oil seeds)

	COW		SHEEP					
	Milk	Col**	Milk	Col**		Contrast[1]		
Fatty Acids	mg/g of FAME				SEM	1	2	3
C10:0			52.2	36.6				
C12:0	16.5	21.47	25.6	29.4	1.15	0.05	0.01	0.05
C14:0	71.5	91.1	126.6	132.4	4.11	0.01	0.04	0.12
C14:1*c*	6.29	5.1	9.33	23.6	0.64	0.23	0.01	0.05
C14:1*t*	1.44	1.15	5.76	1.81	0.07	0.04	0.05	0.05
C16:0	298.	341	260	347	7.12	0.05	0.05	0.05
C16:1	26.6	23.7	25.6	23.4	1.66	0.32	0.28	0.21
C18:0	150	112	79.8	90.3	3.25	0.05	0.05	0.05
C18:1*c*9	333	371	241	319	12.5	0.01	0.05	0.34
C18:1 *t*10	0.37	0.24	0.36	0.27	0.04	0.08	0.06	0.14
C18:1*t*11	11.3	11.9	2.33	3.11	1.45	0.05	0.38	0.01
C18:2*c*9*c*12	18.6	19.5	15.8	27.5	1.41	0.53	0.07	0.05
C18:2*t*10,*c*12	1.39	1.24	1.78	1.44	0.55	0.29	0.41	0.11
C18:2*c*9,*t*11	4.52	3.69	5.71	7.16	0.21	0.05	0.05	0.05
C18:3 n-3	12.3	10.7	15.2	9.79	2.01	0.34	0.21	0.22
C20:5 n-3	0.06	0.098	0.18	0.111	0.002	0.05	0.05	0.05
C22:6 n-3	0.03	0.051	0.133	0.085	0003	0.05	0.06	0.05

[1]1 = contrast between milk verses colostrums (Col**) within cows, 2 = contrast between milk verses colostrums within sheep, 3 = contrast between cows milk verses sheep milk

ii Beef Related Research

Project 1. Influence of Dietary Inclusion Levels of Sunflower Seed on Nutrient Utilization, Performance and Carcass Quality in Feedlot Cattle.

A unique challenge when finishing feedlot animals is to feed the animals in such a manner as to maximize their gains, while maintaining rumen health and continued feed intake. Conventional wisdom would imply that any way to increase the energy in the diet would result in increasing the performance of the animal. Usually this means increasing the grain portion of that diet. Typically in a finishing ration the grain ratio is increased up to some upper sustainable level and held at that point until the animal is ready for slaughter. In many instances the grain portion can be as high as 90-95% of the total diet. A high grain diet causes rapid fermentation and with no fiber present to buffer the rumen, grain overload or acidosis can and will occur. A proportion of that final finishing ration usually needs to remain as forage in order to have some effective fiber level remaining to prevent acidosis, encourage rumination, and maintain overall rumen health. The problem lies in the fact that forages tend to be a good fiber source but a low energy source. Certain fat sources are able to combine an increased energy value with a level of effective fiber. One of these sources is sunflower seed. Sunflower seeds have the unique characteristic that they have a fibrous shell, which can help with rumination, and they contain the energy that is desired in finishing diets. Feeding a fat source such as sunflower seeds can greatly improve the energy content of the diet. Lipids contain about 2.25 times more energy than carbohydrates. Besides providing 2 to 3 times as much net energy as starch, dietary fat does not contribute to acid production and acidosis. Indeed, dietary lipids may inhibit ruminal acidosis. The use of sunflower seeds may also yield an additional benefit by altering the fatty acid profile of the animal and improving carcass quality. Finally high lipid feeds such as sunflowers and flax may become increasingly valuable as a feed source in the event that animal byproduct feeds such as meat and bone meal and potentially tallow are banned or further restricted in ruminant rations. Performance information of cattle fed such products is required in order to fully evaluate their feeding value for finishing cattle.

A performance trial was conducted to determine the effects of sunflower inclusion on average daily gain (ADG), feed intake (FI), and feed efficiency (FE). At the completion of the

trial all animals were slaughtered and carcass parameters were taken for statistical analysis. Twenty eight individual animals were slaughtered and a 7 bone rib section was taken and analyzed for carcass composition and fatty acid analysis as a measure of carcass quality.

Results:

Data from the performance trial was obtained and analyzed to measure differences between treatments in average daily gain (ADG), dry matter intake (DMI), and feed efficiency (FE). Results can be seen in Table 10. These results indicate that sunflower inclusion significantly impacted dry matter intake with intake decreasing in a quadratic manner as inclusion level increased. Average daily gained increased with increasing sunflower addition rate in a quadratic fashion for the first 56 days of the trial but was not different between treatments over the course of the trial. As a result of the differences in intake and gain, feed conversion was significantly improved with sunflower addition rate. Again the results showed that feed efficiency improved with increasing inclusion level up to 10% added sunflowers and then started to drop off at the 15% inclusion level. It would appear from these results that feeding sunflowers at 10% inclusion level will reduce dry matter intake, maintain daily gains and improve feed efficiency in finishing cattle. It is interesting to note that the sunflower seeds were fed whole and that at the 15% inclusion rate were the sole source of fibre for the cattle as no silage was fed. No evidence of acidosis or digestive upsets were evident in these cattle indicating that not only is it unnecessary to process sunflower seeds to cattle prior to feeding but that they served as an effective fibre source for cattle fed diets high in fermentable carbohydrate.

Carcass data was collected from all 200 animals and in detail from 28 animals that were custom killed and 8-bone rib samples dissected for composition and detailed fat analysis. The results are given in Tables 11 and 12. Results from the carcass composition data show a minimal impact of treatment on carcass characteristics, however it should be noted that it was difficult to schedule cattle for kill at the appropriate time due to the problems encountered in the industry with the BSE crisis of 2003-04. The rib data however is based on cattle killed at a similar end-point and other than ribeye area, little effect of treatment was observed. Fat samples were collected from subcutaneous, inter and intra-muscular and body cavity deposits. Table 13 shows the fatty acid profile of body cavity fat samples. Significant relationships can be seen from the analysis. With respect to shorter chain fatty acids (16:0, 16:1 and 17:0), a linear decrease can be

seen with increased sunflower inclusion. The opposite effect can be seen in some of the long chain fatty acids (18:1 t-11, 18:2, and 18:2 t-10,c-12) where a linear increase with increased sunflower inclusion occurs. To a lesser extent, quadratic relationships occur in 17:0, 18:0, and 18:1 c-9, where a quadratic decrease can be seen as sunflower levels increase. In the case of C18:2 c-9, t-11 a quadratic increasing relation ship is show with increasing levels of sunflower inclusion. The effects on linoleic acid (C18:2) content of adipose tissue from cattle fed sunflower seeds is expected as the sunflower seeds were the high linoleic acid variety. High rumen levels of this fatty acid likely inhibit rumen bacterial bio-hydrogenation activities. As a result more of the linoleic acid bypasses the rumen and is available for absorption and deposition into body tissues. Linoleic acid is an essential fatty acid and enrichment in beef products is a potential valuable marketing tool, particularly with respect to human health issues. There was minimal effect of sunflower seed feeding on the primary form of CLA (C18:2 c-9, t-11) although the lesser form C18:2 t-10, c12 was increased. The biological significant of this result is however open to question.

In conclusion the results of this study show that sunflower addition to the diets of finishing cattle at the 10% inclusion level (as fed) in a 80% barley grain based finishing diet resulted in reduced dry matter intake, similar gains and as a result significantly improved feed efficiency relative to cattle fed a standard feedlot finishing diet. No adverse effects on health (i.e. acidosis) or on carcass quality were observed with feeding sunflowers. Effects of sunflower seed inclusion level on fatty acid profile of adipose were most pronounced with linoleic acid (an essential fatty acid) content increasing with sunflower seed inclusion level. No effects were seen on conjugated linoleic acid content.

Table 10. Effects of sunflower seed inclusion rate on dry matter intake (DMI), average daily gain (ADG), and feed efficiency (FC).

	Sunflower Inclusion Rate (%As Fed)					Relationship	
Measurement	0%	5%	10%	15%	SEM	L[a]	Q[a]
Dry Matter Intake (kg/d)							
Day 1-56	9.90	9.39	9.33	9.73	0.108	***	***
Day 56-113	10.57	10.18	10.22	10.23	0.118	*	ns
Overall	10.23	9.79	9.77	9.98	0.094	***	**
Average Daily Gain (kg)							
Day1-56	2.16	2.05	2.08	2.12	0.041	+	+
Day 56-113	1.99	2.05	2.07	2.00	0.040	ns	ns
Overall	2.06	2.03	2.05	2.04	0.032	ns	ns
Feed:Gain							
Day 1-56	4.66	4.66	4.57	4.66	0.093	ns	ns
Day 56-113	6.67	6.07	6.05	6.34	0.190	*	*
Overall	5.52	5.31	5.23	5.40	0.091	*	*

[a]L = Linear; Q = Quadratic relationship;
[a]Significance: NS = P>0.10; + = P >0.05 & <0.10; * = P<0.05; ** = P< 0.01: *** = P< 0.001;
SEM = Standard error of the mean;

Table 11. Effects of sunflower seed inclusion rate on carcass characteristics of finishing cattle.

Carcass Measurement	Sunflower Inclusion Level (%AS Fed) 0%	5%	10%	15%	Relationship L	Q
Weight (kg)						
Live	638.07	635.11	643.57	639.34	ns	ns
Carcass	370.05	368.82	377.70	374.63	ns	ns
Dressing %	59.81	59.93	60.52	60.42	ns	ns
Ribeye Measurement						
Fat 1 (mm)	8.57	7.73	9.42	8.05	ns	ns
Fat 2 (mm)	7.62	6.93	8.52	7.26	ns	ns
Fat 3 (mm)	7.24	6.33	8.05	7.11	ns	ns
Average Fat (mm)	7.80	6.99	8.66	7.48	ns	ns
Grade Fat (mm)	7.19	6.00	7.89	6.63	ns	ns
Ribeye Area (cm)	95.81	91.80	92.16	95.84	+	*
Marbling Score	2.06	2.23	2.18	2.24	ns	ns
Yield Grade	1.08	1.15	1.14	1.10	***	***
Days of Feed	129.88	131.69	133.40	133.42	***	***

[a]L = Linear; Q = Quadratic relationship;
[a]Significance: NS = P>0.10; + = P >0.05 & <0.10; * = P<0.05; ** = P< 0.01; *** = P< 0.001;
SEM = Standard error of the mean;

Table 12. Effects of sunflower seed inclusion rate on characteristics and composition of 8-bon rib sections of finishing cattle.

	Sunflower Inclusion Level (%As Fed)					Relationship	
Measurement	0%	5%	10%	15%	SEM	Linear	Quadratic
Composition %							
Bone	18.60	18.02	16.80	18.69	1.03	ns	ns
Lean	56.98	57.54	53.54	54.41	1.26	ns	ns
Fat	24.43	23.09	28.54	26.89	1.30	ns	ns
Fat Distribution							
Subcutaneous %	29.89	27.12	30.76	29.76	1.37	ns	ns
Body Cavity %	10.66	11.53	9.93	10.61	0.71	ns	ns
Intermuscular %	59.58	61.35	59.31	59.63	1.48	ns	ns
Characteristics							
Fat (mm)	8.71	6.57	9.00	7.71	0.60	ns	ns
Yield Grade	1.85	2.00	2.29	2.29	0.15	ns	ns
Ribeye area (cm^2)	93.14	86.57	83.14	88.00	3.20	*	+
% Lean	60.86	61.17	58.79	60.60	0.83	ns	ns
Marbling Score[b]	8.14	7.93	7.74	7.51	0.24	ns	ns
Fat Color	1.42	1.14	1.28	1.00	0.15	ns	ns
Fat Texture	1.00	1.00	1.14	1.00	0.07	ns	ns
Meat Color	1.42	1.86	1.57	1.14	0.27	ns	ns
Meat Texture	1.57	2.21	1.50	1.71	0.24	ns	ns
Marbling Texture	2.21	2.50	2.36	3.00	0.33	ns	ns

[a]L = Linear; Q = Quadratic relationship;
[a]NS = P>0.10; + = P >0.05 & <0.10; * = P<0.05; ** = P< 0.01: *** = P< 0.001;
[b] Marbling score: 7 = Small (Canada AAA); 8 = Slight (Canada AA); 9 = Trace (Canada A);
SEM = Standard error of the mean;

Table 13. Fatty composition of kidney fat from cattle fed graded levels of sunflower seeds

Fatty Acid	Treatment (g/100g)				SEM	Relationship	
	Control	5% Sunflower	10% Sunflower	15% Sunflower		L	Q
C14:0	5.24	5.14	5.10	5.04	0.33	NS	NS
C14:1	0.32	0.44	0.38	0.40	0.06	NS	NS
C15:0	0.64	0.60	0.55	0.58	0.03	NS	NS
C16:0	29.55	29.45	27.50	26.80	0.82	*	NS
C16:1	1.72	1.44	1.53	1.30	0.12	*	NS
C17:0	2.41	1.97	1.87	1.66	0.06	***	+
C18:0	22.73	25.30	23.16	22.59	0.84	NS	+
C18:1 c-9	28.19	22.49	23.05	22.44	0.92	***	*
C18:1 t-11	6.18	9.35	12.48	13.76	0.91	***	NS
C18:2	1.61	2.58	2.94	3.98	0.22	***	NS
C18:2 c-9,t-11	0.73	0.53	0.71	0.72	0.05	NS	*
C18:2 t-10, c-12	0.04	0.09	0.10	0.11	0.02	+	NS
C18:3	0.30	0.25	0.27	0.28	0.02	NS	NS
C20:0	0.04	0.01	0.04	0.02	0.01	NS	NS
C22:0	0.08	0.08	0.07	0.06	0.02	NS	NS

Notes: NS = P>0.10; + = 0.05<P<0.10; * = P<0.05; ** = P< 0.01: *** = P< 0.001
L= Linear effect; Q = Quadratic effect.

Project 2: Strategic Inclusion of High Lipid Feeds on Performance and Carcass Characteristics of Cattle

High lipid feeds such as flax and sunflower seeds are generally not price competitive in feedlot diets. However, market changes are occurring (i.e. increasing resistance to feeds of animal origin such as tallow and meat and bone meal), as well there is increasing interest in changing the fatty acid profile of beef products to that which is thought to be more consistent with good health. In this light, feed ingredients such as flax and sunflower seeds may find a future niche in cattle diets. Drouillard et al. (2001) reports improved growth performance and immunity for cattle receiving diets containing flaxseed upon arrival in the feedlot. Waylan et al. (2004) cite LaBrune (2000) as showing that flaxseed feeding partitions fatty acids to adipose tissue increasing marbling. Dunn et al. (2003) found flaxseed feeding to affect IGF-1 levels and cite Liu et al. (1994) with reporting that polyunsaturated fatty acids increase IGF-1 binding. Both of the findings suggest flaxseed may increase yield grade through altered IGF-1 signaling. Lastly, Drouillard et al. (2002) report that feeding flaxseed for the first 5-6 wk at the feedlot resulted in improved marbling and quality grade at slaughter even though flax had not been fed for the last 150 d on feed. Strategic feeding of sunflower seeds in a similar fashion has not been carried out. The objectives of this trial were to determine the feedlot performance of cattle fed flax or sunflower seeds either in the first 60 or the last 60 days of the feeding period on health, performance and carcass traits.

Materials and Methods

Animals and Dietary Treatments

During 2003-2004, a steer feeding trial was conducted at the University of Saskatchewan Beef Research Centre in Saskatoon, Saskatchewan. On November 26, 2003, 250 cross-bred steer calves (342 ± 19 kg BW) were stratified by weight and assigned randomly to one of 25 pens (10 steers per pen). Each pen of steers was then assigned randomly to one of five dietary treatments. Dietary treatments were: 1) a control diet based on barley silage, rolled barley grain, and grass hay; 2) control diet with addition of ground flax seed for the first 60 d; 3) control diet with addition of whole sunflower seed for the first 60 d, 4) control diet with ground flax seed for the last 60 d; and 5) control diet with whole sunflower seed for the last 60 d. Exact composition of the experimental diets varied throughout the feeding period (i.e a step-up feeding program was used) and composition on an as fed or wet weight basis for the diets and the pelleted supplements

are presented in Tables 14 and 15. Whole sunflower seed for this trial were provided by Pioneer Hibred Seeds and flax seed by the Saskatchewan Flax Development Commission.

Animal Housing and Care

Steers were housed in outdoor pens with protection from prevailing winds via 20% porosity fencing and surrounding tree windbreaks. Feed was delivered a minimum of once daily to allow for *ad libitum* intake. Water was continually available for *ad libitum* consumption from automatic waters. All animal care met standards established by the Canadian Council on Animal Care (1993).

Data and Measures

Animal weights. The steers involved in this trial were weighed twice at the beginning of the trial on November 25 and 26, 2003, at the end of the backgrounding period on January 23 and 24, 2004, and the end of the trial prior to slaughter (varied by animal). Animal body weights were also recorded on two week intervals throughout the backgrounding and finishing periods. All weights were made in the morning prior to delivery of feed.

Feed intakes. The amount of feed provided to each pen of steers was recorded twice daily. Periodic weights of refused feed allowed calculation of feed intake. Samples of feed ingredients collected at weekly intervals and dried at 60 °C allowed correction to a DM basis. Records on animal removal for slaughtered allow expression of feed intake on a per animal basis and determination of pen average days on feed.

Ultrasound data. Ultrasound measures of individual animal backfat and ribeye area were made shortly after the beginning of the trial (+12 d) and end of the backgrounding period (+10 d), on December 8, 2003 and February 2, 2004, respectively, and at the end of the trial prior to slaughter (varied by animal). Ultrasound measures of backfat were also made periodically during the finishing period for the purpose of tracking the rate of fattening.

Carcass characteristics. Steers were slaughtered at a federally inspected packing plant. Data collected on carcass characteristics of steers was obtained through the Canadian Beef Grading Agency and included hot carcass weight, average fat, grader estimated back fat, ribeye areas, marbling scores, and ruler yields. Carcass dress was calculated from hot carcass weight and end of test live weight. Fatty acid composition was carried out on a sub-set of the animals that were killed at a set end point as determined by ultrasound. All fatty acid work was carried out using gas chromatography with the assistance of Dr. Shannon Scott of the Brandon Agriculture and Agri-Food Canada Research Station.

Statistical Analysis

All feedlot performance and carcass characteristic data were analyzed using the mixed models procedure of SAS (SAS Inst. Inc., Cary, NC) with individual pens of steers as the experimental unit. All treatment comparisons were made using protected least significant difference tests at $\alpha = 0.05$. Steers on the ground flax and whole sunflower seed treatments for the last 60 d received the control diet until March 4, 2004 (d 100). Therefore, data on these steers were combined with steers on the control treatment using contrasts for treatment comparisons with data collected up to and including the end of the backgrounding period.

Results and Discussion

Averaged over the course of the trial, the DM content of rolled barley grain, barley silage, grass hay, and supplement pellets (all formulations) were 93, 34, 88, and 91%, respectively. For the first 60d, ground flax and whole sunflower seed averaged 94, and 89% DM, respectively. For the last 60 d, ground flax and whole sunflower seed averaged 87, and 86% DM. Treatment means for all feedlot performance and carcass characteristic measures are presented in Table 16.

Start of Trial

Owing to the randomization of steers to individual pens and individual pens to experimental treatments, there was no treatment effect ($P > 0.05$) observed on initial weight, ultrasound backfat, or ultrasound ribeye area.

Backgrounding

Steers fed ground flax or whole sunflower seed for the first 60 d consumed 5 or 8%, respectively, less ($P < 0.05$) feed than the average of the steers on the control diet during the backgrounding period. This reduction in feed consumption resulted in 3 and 14% lower ($P < 0.05$) ADG for the steers fed ground flax or whole sunflower seed for the first 60 d, respectively, when compared to the average ADG for steers on the control diets. However, ADG for all treatment groups averaged 1.46 kg/d, a relatively high rate of gain for steers in a backgrounding program and indicating good consumption of a moderately high energy diet. That the reduction in ADG observed for steers fed ground flax or whole sunflower seed for the first 60 d was caused by the decreased DMI is supported by the observation that there was no effect ($P > 0.05$) of dietary treatment on the feed efficiency of steers. The effect of dietary treatment on ultrasound backfat gain paralleled the effects observed for DMI and ADG. Ultrasound backfat gains were 45 and 46% lower ($P < 0.05$) for steers that had received the ground flax or whole sunflower seed for the first 60 d, respectively, when compared to steers fed the control diet. Given that a

major objective of backgrounding programs is to allow cattle to mature and increase in size without fattening, the lower backfat gains observed for are indicative of a more successful backgrounding program. Lack of effect ($P > 0.05$) of dietary treatment on ultrasound ribeye area gain indicates that lean tissue development of steers was able to progress normally and independent of dietary treatment.

End of Backgrounding

The lower ADG observed during the backgrounding period resulted in end of backgrounding weights that were 1 and 3% lower ($P < 0.05$) for steers that had received the ground flax or whole sunflower seed for the first 60 d, respectively, when compared to the average of the steers receiving the control diet. The lower ultrasound backfat gain resulted in end of backgrounding period ultrasound backfat being 16 and 26% lower ($P< 0.05$) for steers that had received the ground flax or whole sunflower seed for the first 60 d, respectively, when compared to the average of the steers receiving the control diet. There was no effect ($P > 0.05$) of dietary treatment on ultrasound ribeye area indicating that the observed effects of dietary treatments on ADG and ultrasound backfat were not substantial enough to impact lean tissue development.

Finishing

There were no ($P > 0.05$) effects of dietary treatment on DMI, ADG, feed efficiency, days on feed, and ultrasound backfat or ribeye area gain during the finishing period. This indicates that the effect of dietary treatment on DMI, ADG, and ultrasound backfat gain observed during the backgrounding period were likely dependent on stage of production.

End of Test and Carcass Characteristics

By completion of the feeding trial, there were no ($P > 0.05$) treatment effects on any observed parameters except end of test ultrasound ribeye area, grader ribeye area, and ruler yield ($P < 0.05$). This indicates that the treatment effects that manifested during the backgrounding period were transitory and minor in nature. With regard to the effect of treatment on ultrasound ribeye area at the end of the trial, steers that received the control diet throughout the trial had ribeye areas that were 4% smaller ($P < 0.05$) than the average of the steers that had received ground flax or whole sunflower during the trial. There were no differences ($P > 0.05$) between steers that received ground flax or whole sunflower during the first or last 60 d of the trial. Similar results were observed for grader ribeye area, although steers that received whole sunflower seed during the last 60 d were not found to differ ($P > 0.05$) from the control

treatment. Ruler yield is estimated from ribeye length, width, and external fat. The effect of treatments on ribeye area explain the effects observed with ruler yield, although only cattle that received ground flax or whole sunflower seed during the first 60 d were found to have greater ($P < 0.05$) ruler yields than the control treatment.

Providing an explanation for the observed effect of ground flax or whole sunflower inclusion into feedlot diets on ribeye area is particularly challenging due to: 1) the observation that the increase in ribeye area appears to be independent of when the ground flax or whole sunflower seed was fed; and 2) the failure to observe this effect at the end of the backgrounding period with cattle that had been fed ground flax or whole sunflower seed for the first 60 d. A plausible explanation is that the fatty acids supplied by ground flax or whole sunflower were involved in altered cellular signaling, most likely through conversion to a variety of eicosanoid substances including leukotrienes, prostaglandins, thromboxanes and prostacyclins. This explanation is supported by Dunn et al. (2003) who found flax feeding to alter IGF-1 and cited Liu et al. (1994) with increased polyunsaturated fatty acids as improving IGF-1 binding. Intracellular signal propagation resulting from IGF-1 binding is known to involve membrane bound arachidonic acid (Voet and Voet, 1995) and flax feeding during the backgrounding or finishing periods would result in increased membrane bound arachidonic acid levels for later involvement in cellular signaling. Steers that received ground flax or whole sunflower during the first 60 d would have been dependent on cellular stores of dietary fat for initiating altered cellular signaling. The failure to detect a treatment effect at the end of the backgrounding period further suggests that this altered cellular signaling was only of importance during the finishing period.

Failure to detect a treatment effect on marbling scores may be attributed to individual steers being sent to slaughter at a similar backfat endpoint of approximately 8-9 mm. Had the steers been fed to a fatter endpoint as is common in the United States, and all cattle marketed at the same time as is common with commercial feedlots, it is quite possible that marbling scores would have been higher for cattle receiving ground flax or whole sunflower seed.

Fatty acid analysis of ribeye samples from selected animals fed all 5 diets are presented in Tables 17-19. Table 17 shows that there was no effect of flax or sunflower seed feeding on short chain (C8 to C16) fatty acid content of ribeye tissues. M acid was increased by sunflower seed feeding for the last 16 days of the trial, however the reason for this is not clear. Oleic (C18:1 c9) was significantly reduced by both flax and sunflower seed feeding during the last 60 days of the trial. This result is expected in light of increases noted in linoleic (C18:2) and linolenic (C18:3) content of ribeye tissue from cattle fed sunflower and flax during the last 60 days of the trial, respectively (Table 18). The drop in C18:1 c9 likely corresponds to more

linoleic and linolenic acid escaping the rumen biohydrogenation in cattle fed sunflower and flax diets, respectively. The increase in linoleic acid content with sunflower seed feeding mirrors that seen in our first study. Both linoleic and linolenic acids are essential fatty acids and the results of this study point to a method of dietary manipulation of carcass beef that has the potential to be marketed as a value-added product with potential positive implications for human health. Minimal effects, particularly of biological significance were seen on longer chain fatty acids (C20 to C22).

Conclusion and Implications

The results of this trial indicate that inclusion of ground flax or whole sunflower into the diet of feedlot cattle may result in an initial and transitory decline in intake with subsequent impacts on gain. However, by the time cattle were sent to slaughter, the only impact of dietary inclusion of ground flax or whole sunflower was an increase in ribeye area with subsequent impact on estimated yield. Fatty acid profile of fat extracted from ribeye tissue showed that sunflower feeding during the last 60 days increased the linoleic acid content while flax feeding increased the linoleic acid content of beef. Both are essential in the human diet and thus such feeding may pose a route to value-added beef products in a manner beneficial to human health.

Acknowledgements

We would like to thank Dr. Shannon Scott of the Agriculture and Agri-Food Canada Research Station at Brandon, Mb. for conducting the fatty acid analysis of the ribeye samples and to the Agriculture Development Fund for funding this work.

Table 14. Feed ingredient composition of diets fed to steers, kg per kg wet weight basis.

Diet / Feed Ingredients	Day of Trial											
	1	2 – 5	6 - 9	10 – 62	63 - 65	66 - 68	69 - 71	72 – 74	75 - 79	80 - 99	100 - 103	104 - End
Control												
Barley silage	0.450	0.450	0.450	0.400	0.400	0.400	0.350	0.300	0.260	0.200	0.155	0.155
Rolled barley grain	0.100	0.200	0.300	0.400	0.400	0.400	0.500	0.600	0.700	0.760	0.800	0.800
Pelleted supplement[a]	0.050	0.050	0.050	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.045	0.045
Grass hay	0.400	0.300	0.200	0.160	0.160	0.160	0.110	0.060	-	-	-	-
Flax/Sunflower - 1st 60 days												
Barley silage	0.450	0.450	0.450	0.400	0.400	0.400	0.350	0.300	0.260	0.200	0.155	0.155
Rolled barley grain	0.100	0.150	0.200	0.260	0.330	0.400	0.500	0.600	0.700	0.760	0.800	0.800
Pelleted supplement[a]	0.050	0.050	0.050	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.045	0.045
Grass hay	0.400	0.300	0.250	0.230	0.230	0.160	0.110	0.060	-	-	-	-
Ground flax or whole sunflower	-	0.050	0.050	0.070	-	-	-	-	-	-	-	-
Flax/Sunflower - Last 60 days												
Barley silage	0.450	0.450	0.450	0.400	0.400	0.400	0.350	0.300	0.260	0.200	0.155	0.155
Rolled barley grain	0.100	0.200	0.300	0.400	0.400	0.400	0.500	0.600	0.700	0.760	0.750	0.730
Pelleted supplement[a]	0.050	0.050	0.050	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.045	0.045
Grass hay	0.400	0.300	0.200	0.160	0.160	0.160	0.110	0.060	-	-	-	-
Ground flax or whole sunflower	-	-	-	-	-	-	-	-	-	-	0.050	0.070

[a] The supplemental pellets fed were formulated to provide monensin () at 30 mg per kg, vitamins A and D, and trace mineral salt (). Cattle receiving ground flax or whole sunflower seed were fed a different supplement with lower levels of protein and Ca to reflect the higher levels of these nutrients supplied by the ground flax or sunflower seed. Feed ingredient composition of supplement pellets is present in Table 2.

Table 15. Feed ingredient composition of pelleted supplements[1], kg per kg wet weight basis.

Diet / Feed Ingredients	Date of Implementation		
	Nov. 2003	Feb. 13, 2004	Feb. 28, 2004
Pelleted Supplement for diets not containing ground flax or whole sunflower			
Barley grain	0.125	0.080	0.000
Tallow	0.032	0.032	0.032
Molasses	0.033	0.033	0.033
Canola meal	0.350	0.500	0.478
Limestone	0.220	0.110	0.210
Vitamin E premix	0.000	0.000	0.002
Monensin premix	0.080	0.080	0.080
Trace mineral salt	0.060	0.065	0.065
Vitamin premix	0.100	0.100	0.100
Pelleted Supplement for diets containing ground flax or whole sunflower			
Barley grain	0.580	0.520	0.468
Tallow	0.320	0.032	0.032
Molasses	0.330	0.033	0.033
Canola meal	0.000	0.000	0.000
Limestone	0.110	0.220	0.220
Vitamin E premix	0.000	0.000	0.002
Monensin premix	0.080	0.080	0.080
Trace mineral salt	0.065	0.045	0.065
Vitamin premix	0.100	0.070	0.100

[1] Cattle receiving ground flax or whole sunflower seed were fed a different supplement with lower levels of protein and Ca to reflect the higher levels of these nutrients supplied by the ground flax or sunflower seed.

Table 16. Effect[1] of dietary treatments on feedlot performance and carcass characteristics.

	Control	Ground flax		Whole sunflower		SE	P value
		1st 60 days	Last 60 days	1st 60 days	Last 60 days		
DMI, kg/d							
Backgrounding	9.36a	8.90b	9.51a	8.60b	9.16a	0.14	0.0010
Finishing	10.60	10.92	10.59	10.81	10.72	0.15	0.4807
Total	10.22	10.28	10.25	10.12	10.24	0.12	0.8982
Body weight, kg							
Start of test	343.3	342.8	342.9	343.3	343.3	0.3	0.6738
End of backgrounding	434.2a	429.2a	432.3a	419.9b	431.2a	2.4	0.0034
End of test	619.9	625.4	623.8	623.9	621.6	3.1	0.7473
ADG, kg							
Backgrounding	1.540a	1.466a	1.516a	1.299b	1.490a	0.039	0.0022
Finishing	1.644	1.766	1.747	1.754	1.712	0.040	0.2313
Total	1.608	1.662	1.666	1.600	1.635	0.034	0.5651
Feed efficiency, ADG, kg / DMI, kg/d							
Backgrounding	0.1645	0.1646	0.1597	0.1510	0.1628	0.0038	0.0973
Finishing	0.1551	0.1617	0.1649	0.1621	0.1597	0.0026	0.1402
Total	0.1574	0.1616	0.1626	0.1580	0.1597	0.0025	0.5577
Days on feed							
Finishing	113.2	111.1	109.9	116.8	111.3	2.5	0.3502
Total	172.2	170.1	168.9	175.8	170.3	2.5	0.3502
Ultrasound backfat, mm							
Start of test	2.28	2.53	2.02	2.08	2.30	0.18	0.3125
End of backgrounding	4.77a	3.80b	3.99a	3.31b	4.74a	0.28	0.0058
End of test	9.14	8.29	8.20	7.92	9.24	0.37	0.0735
Ultrasound backfat gain, mm							
Backgrounding	2.48a	1.27b	1.97a	1.23b	2.44a	0.22	0.0008
Finishing	4.37	4.49	4.21	4.61	4.50	0.26	0.8450
Total	6.86a	5.76b	6.18ab	5.84b	6.94a	0.32	0.0411
Ribeye area, cm^2							
Start of test	64.53	65.45	64.84	64.88	66.52	1.16	0.7659
End of backgrounding	72.77	75.27	76.00	73.87	75.67	1.25	0.3537
End of test	93.96b	98.07a	98.77a	97.19a	99.03a	0.99	0.0112
Ribeye area gain, cm^2							
Backgrounding	8.24	9.82	11.16	8.99	9.15	1.32	0.6091
Finishing	21.19	22.80	22.78	23.32	23.36	1.16	0.6799
Total	29.43	32.62	33.93	32.31	32.51	1.08	0.0880
Carcass characteristics							
Hot carcass weight, kg	355.5	354.6	356.3	356.9	355.1	1.6	0.8493
Average backfat, mm	9.27	8.03	8.12	7.98	9.01	0.38	0.0734
Grade fat, mm	8.14	7.16	7.06	6.88	8.02	0.37	0.0791
Grade ribeye area, cm^2	91.10b	95.26a	95.80a	94.76a	93.08ab	0.99	0.0200
Marbling score	7.86	7.74	7.84	7.92	7.78	0.05	0.1410
Ruler yield	60.14b	61.50a	61.22ab	61.64a	60.22b	0.38	0.0257
Carcass dress, %	57.34	56.71	57.12	57.21	57.14	0.26	0.5193

[1] Ground flax and whole sunflower inclusion for the last 60 d treatments were combined with the control treatment for comparisons involving data collected by the end of the backgrounding period.

a,b Means followed by different letters differ ($P > 0.05$).

Table 17. Effect of oilseed feeding on the content of fatty acids C8 through C16 in the tissues of beef steers[z].

	Treatment LS Means					Pooled SE	P-value
	Control	Flax		Sunflower			
		1st 60 d	Last 60 d	1st 60 d	Last 60 d		
Fatty acid (mg per 100 mg lipid)							
C8:0	0.000	0.043	0.039	0.000	0.000	0.024	0.4843
C9:0	-	-	-	-	-	-	-
C10:0	-	-	-	-	-	-	-
C12:0	0.071	0.072	0.083	0.089	0.076	0.013	0.8443
C13:0	0.077	0.076	0.094	0.083	0.075	0.012	0.7725
C14:0	-	-	-	-	-	-	-
C14:1 (cis)	1.56	1.52	1.90	1.71	1.78	0.11	0.1260
C15:0	0.96	0.91	0.97	1.15	0.91	0.16	0.8285
C16:0	22.28	22.12	22.30	23.01	22.87	0.78	0.9013
C16:1 (trans)	0.177	0.186	0.274	0.267	0.203	0.051	0.5370
C16:1 (cis)	3.43	3.19	3.30	3.16	3.43	0.23	0.8728

[z] Total fatty acids identified for control, flax for the first 60 d, flax for the last 60 d, sunflower for the first 60 d, and sunflower for the last 60 d were 82.99, 80.87, 78.53, 84.16, and 81.50 mg per 100 mg of lipid and did not differ ($P = 0.4176$; pooled SE = 2.05).

Table 18. Effect of oilseed feeding on the content of C17 and C18 fatty acids in the tissues of beef steers[z].

	Treatment LS Means					Pooled SE	P-value
	Control	Flax		Sunflower			
		1st 60 d	Last 60 d	1st 60 d	Last 60 d		
Fatty acid (mg per 100 mg lipid)							
C17:0	1.268a	1.279a	1.249a	1.702b	1.355a	0.073	0.0025
C17:1	0.88	0.85	0.80	1.01	0.65	0.10	0.1715
C18:0	10.99	11.23	10.59	11.50	10.84	0.60	0.8614
C18:1(trans-9)	0.00	0.00	0.00	0.00	0.57	0.30	0.5295
C18:1(trans-11)	1.66	2.01	2.22	2.67	2.26	0.39	0.4705
C18:1(cis-9)	36.2a	34.1ab	30.8b	33.3ab	32.0b	1.2	0.0462
C18:2 (t,t)	0.035	0.032	0.042	0.020	0.019	0.012	0.6407
C18:2 (c,c)	1.80a	1.66a	1.90ab	2.54bc	3.02c	0.25	0.0046
C18:3 (gamma)	0.0109	0.1463	0.0066	0.0280	0.0221	0.0058	0.1220
C18:3	0.256a	0.306a	0.767b	0.274a	0.231a	0.048	0.0001
CLA (c9-t11)	0.340	0.379	0.305	0.326	0.262	0.041	0.3710
CLA (t10-c12)	0.0047	0.0070	0.0032	0.0053	0.0197	0.0047	0.1046

a,b,c Treatment LS Means not followed by the same letter differ ($P < 0.05$).

[z] Total fatty acids identified for control, flax for the first 60 d, flax for the last 60 d, sunflower for the first 60 d, and sunflower for the last 60 d were 82.99, 80.87, 78.53, 84.16, and 81.50 mg per 100 mg of lipid and did not differ ($P = 0.4176$; pooled SE = 2.05).

Table 19. Effect of oilseed feeding on the content of fatty acids longer than C18 in the tissues of beef steers[z].

	Treatment LS Means					Pooled SE	P-value
	Control	Flax		Sunflower			
		1st 60 d	Last 60 d	1st 60 d	Last 60 d		
Fatty acid (mg per 100 mg lipid)							
C20:0	0.0664ab	0.0761b	0.0865b	0.0677ab	0.0507a	0.0082	0.0671
C20:1	0.170	0.163	0.143	0.163	0.108	0.020	0.1682
C22:0	0.035	0.041	0.038	0.036	0.036	0.010	0.9949
C20:4	0.372	0.299	0.290	0.589	0.413	0.099	0.2771
C20:5 (EPA)	0.095	0.099	0.113	0.127	0.088	0.024	0.8031
C22:5 (DPA)	0.223	0.200	0.218	0.290	0.213	0.052	0.7834
C22:6 (DHA)	0.0143	0.0100	0.0063	0.0058	0.0120	0.0068	0.8738

a,b, Treatment LS Means not followed by the same letter differ ($P < 0.05$).

[z] Total fatty acids identified for control, flax for the first 60 d, flax for the last 60 d, sunflower for the first 60 d, and sunflower for the last 60 d were 82.99, 80.87, 78.53, 84.16, and 81.50 mg per 100 mg of lipid and did not differ ($P = 0.4176$; pooled SE = 2.05).

Overall Conclusions:

Knowledge gained from this research will enable greater understanding of the effects of an unsaturated fat source on performance and product quality of lactating and growing cattle. From the point of view of providing energy and protein to high performance ruminant animals, high lipid feeds such as flax and sunflower have proven to be of equal or superior to conventional feeds. Nutritionists need to recognize the limitations on fat levels of ruminant diets and not exceed 7% of the diet dry matter in order to minimize intake and digestibility concerns. Economics of these feeds also have to be considered when including in the diet. Of particular significance is the increased content of dairy and beef products from cattle fed sunflower and flax. Increased content of essential fatty acids such as linoleic acid, conjugated linoleic acid and linolenic acid offer the potential to value add ruminant products and market to domestic and international consumers who focus on health issues.

B. Personnel

Amanda Kroeker M.Sc. candidate is supported from this project. Henry Soita research associate is supported from the ADF Strategic Project on ruminant nutrition and biochemistry; however some operating funds from this project are used to support his work. In addition, Murray Ernst was been appointed as a M.Sc. student on this project with assistance from Teresa Binetruy and Tyler Turner (research technicians).

C. Equipment

Approximately $500.00 had been expended for 2 gas chromatography columns and $450 for scale head for weights. .

F. Project Development Materials

Amanda Kroeker and Murray Ernst have prepared posters from their work and Henry Soita presented results at the recent Canadian Society of Animal Science Meeting in Saskatoon.

G. Project Photos

Some project photos are on file.

H. Acknowledgement

Support from SADF has been acknowledged in Henry Soita's presentation and will be included in Amanda Kroeker's and Murray Ernst thesis, as well as at extension activities..

I. Expense Statement

Provided by the University of Saskatchewan research account's office.

J. ICAR Data Entry

Previously submitted.